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## Research publication trend among the scientists of Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram: A Scientometric Study

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Bibliographic details of 1076 research articles obtained from the annual reports of Central Tuber Crops Research Institute (CTCRI) were studied and it was found that the highest number of 169 papers was published in the year 2006 and the average number of publications per year was 97.82. Most of the contributions were multi authored (87.68%). The degree of collaboration of scientists of CTCRI was 0.87 and most of the articles published by the scientists were in the foreign journals (51.89%). *Journal of Root Crop* published by Indian Society of Root Crops tops the list with the highest number of articles 125 (39.30%). Applicability of Bradford's Law in the journal distribution pattern of the CTCRI scientists does not fit the Bradford's distribution pattern.

**Keywords:** Bradford's Law, Scientometrics, Bibliometrics, Tuber crops

### Introduction

Scientific productivity in the form of intellectual contributions communicated in a written form is important to the scientific community. It is measured through publications and citation data. Scientometrics involves quantitative studies of scientific activities.<sup>1</sup>

Roots and tuber crops occupy a remarkable position in the food security of the developing world due to their high calorific value and carbohydrate content. Tuber crops form an important staple food crop in the tropics. These crops produce high level of calories and carbohydrates from a unit area and unit time and they can withstand adverse biotic and abiotic conditions. The major tropical root crops are cassava, sweet potato, yams and aroids. In addition to the major crops there are many types of tuberous and rhizomatous minor root crops which are grown and used in different parts of the country<sup>2</sup>.

Research on tuber crops at global level is being carried out in many of the international research centres and at the national level it is being done in the CTCRI.

In the present study, the investigators attempt to make an analysis of the research publication in tuber crops that have emanated from the CTCRI, Thiruvananthapuram by applying scientometric techniques.

### Central Tuber Crops Research Institute

Central Tuber Crops Research Institute (CTCRI) started functioning as a research institute under Indian Council of Agricultural Research (ICAR) in July 1963 with its head quarters at Sreekariyam, near Thiruvananthapuram. The institute has a regional centre located at Aiginia, Bhubaneswar, Odisha. The CTCRI is the only one of its kind in the world dedicated solely to the research on tropical tuber crops. Nearly four decades of concerted research have led to the development of several production and processing technologies for tuber crops besides release of nearly 50 improved varieties. The target group of most of the technologies being small holding and resource poor farmers, adequate emphasis is also given for on farm evaluation and popularization of the technologies. In addition, several industrial hi-tech technologies have been developed in the recent past enabling resource generation through consultancies<sup>3</sup>.

The Institute is also the head quarters for the Indian Society for Root Crops (ISRC), a scientific society, established in 1971 devoted to the research and development of tropical tuber crops. ISRC also publishes the *Journal of Root Crops* (biannual). The institute has strength of 41 scientific and 88 other members of the staff. The administrative, technical

and farm wings of the institute carry out the jobs pertaining to administration, technical and farm management matters.

CTCRI bagged the Sardar Patel Outstanding Institution Award for the year 2005 instituted by the ICAR for outstanding contribution made in the improvement of tropical tuber crops and development of low cost production technologies. The centre is recognized by the University of Kerala and the CTCRI Regional Centre by the Utkal University, Odisha as centres for Post-graduate studies programme. So far 12 scholars have been awarded doctoral degrees under the guidance of scientists of CTCRI and at present 12 scholars are pursuing their programmes<sup>4</sup>.

### Review of literature

A number of quantitative studies based on scientometric techniques have been reported to evaluate the research productivity of individuals, institutions, countries, etc. Studies are also available to verify the fitness of classic laws of bibliometrics, factors of productivity and impact of research conducted in various countries. These studies are very much helpful to assess the development of science as well as in their application to library and information resource management also.

Kaushik<sup>5</sup> identified various bibliometric aspects of the scientific contributions of the researchers and faculty of National Dairy Research Institute (NDRI), Karnal published during 2001-2011. The average number of authors per contribution was 3.61 and degree of collaboration 0.98. The NDRI scientists had foreign collaboration with nineteen countries and collective research trend is predominant among the scientists. Jeyshankar, Ramesh Babu and Rajendran<sup>6</sup> analysed bibliographical details of 1282 research articles published by the scientists of CECRI during the period 2000-2009. It was found that 2009 was the most productive year with 194 articles and collaborative research was dominant with the highest degree of collaboration being 0.98 in the year 2005.

Sudhier and Abhila<sup>7</sup> analyzed the research productivity of social scientists at the Centre for Development Studies (CDS), Thiruvananthapuram during 1998-2008. There were 599 research papers published during the period, including 38.23% journal articles and 15.03% working papers. More than 66% journal articles were published in Indian journals. Sahu, Goswami and Choudhary<sup>8</sup> analysed R & D

publication growth and its characteristics with reference to the National Metallurgical Laboratory, an R & D institution under CSIR based on data obtained from the Science Citation Index. It was found that the highest number of 120 papers was published by the laboratory in the year 2010 out of which 28 papers received 62 citations during the same period. The average number of publications per year was 88.1 and the average citation per paper was 5.02.

Bhatia<sup>9</sup> analyzed quantitatively the research publications published by the scientists of National Institute of Occupational Health (ICMR) Ahmedabad, India during 2002-2006. Okafor and Dike<sup>10</sup> analyzed the research output of academics in the science and engineering faculties of Federal Government-owned universities in Nigeria. Mahbuba, Rousseau and Srivastava<sup>11</sup> did a scientometric comparison between two health and population research organizations, namely the International Centre for Diarrheal Research in Bangladesh (ICDDR) and National Institute of Cholera And Enteric Diseases (NICED) in India during the period 1979 – 2008.

Sudhier<sup>12</sup> in his scientometric study analysed the publications of physics researchers at the Indian Institute of Science (IISc), Bengaluru. There were 267 papers published during 1999-2003 and the highest number of papers was in the year 2001. The average number of authors per article was 4 and the degree of collaboration was 0.94. Girap and others<sup>13</sup> conducted a scientometric analysis of the publications of Technical Physics and Prototype Engineering Division at Bhabha Atomic Research Centre. There were 704 papers published during 1986-2006 scattered in diverse domains like crystals (192), thin films (173) and glasses and ceramics (102). The average number of publications per year was 33.52 and the most prolific authors were: S. K. Gupta (215), G.P. Kothiyal (171) and S. C. Sabharwal (151).

Maheswaran, Kumar and Sridharan<sup>14</sup> conducted a study based on the research publications generated by Structural Engineering Research Centre (SERC) during the years 2002-2006. A bibliometric study of research publication trend among scientists of Central Potato Research was studied by Sharma<sup>15</sup>. A total of 2603 research articles published by the scientists of CPRI during 1991 to 2007 were collected by scanning of annual reports and *Journal of the Indian Potato Association*. Bala and Gupta<sup>16</sup> studied growth and impact of research output of Government Medical

College and Hospital, Chandigarh. Kumbar, Gupta and Dhawan<sup>17</sup> described the growth, contribution and impact of research carried out by the scientists of University of Mysore in S & T. Mukherjee<sup>18</sup> analyzed the authorship pattern of scientific productions of the four most productive Indian academic institutions for the eight year period from 2000 to 2007. Sevukan and Sharma<sup>19</sup> in their bibliometric analysis, studied the research output of biotechnology faculties in some Indian central universities.

Jeevan and Sen<sup>20</sup> conducted a study based on the journal publications generated by the Inter University Accelerator Centre, and the Accelerator Group at the Tata Institute of Fundamental Research (TIFR) during 1997-1999. The data was collected from the annual reports and the impact was examined using data from SCI. Out of the three specialization in NSC, material science was more productive in terms of publication whereas higher percentage qualitative papers originated from nuclear physics. Radiation biology had a very nominal presence. Dhawan and Gupta<sup>21</sup> studied the institutional performance, based on publications output of physics research from India. Scientometric analysis of 1044 papers published by the scientists of Radiochemistry division at Bhabha Atomic Research Centre (BARC) during 1958-2005 in diverse domains were conducted by Kademani and others<sup>22</sup>. The highest number of 64 publications were produced in 2005 and the average number of publication per year was 21.75. Publication concentration was 6.06 and publication density was 5.27.

Several studies have been reported in the area of scientometrics on institutional productivity, particularly in the Indian context and a few of them were: Angadi et al<sup>23</sup> on the Tata Institute of Social Sciences during 2001-2004, Kademani et al<sup>24</sup> on the Analytical Chemistry Division of BARC during 1972-2003, Kademani et al.<sup>25</sup> in the Bio-organic division of BARC, Mehta<sup>26</sup> on National Chemical Laboratory (NCL), Pune, Gopikuttan<sup>27</sup> on the Science Departments, Faculty of Science, University of Kerala during 1980-1999, Jeevan and Gupta<sup>28</sup> on IIT, Kharagpur, Gupta et al.<sup>29</sup> on the Council of Scientific & Industrial Research (CSIR) and Garg and Rao<sup>30</sup> in the Indian Physics Laboratory.

Many scholars have studied the institutional productivity of scientists and researchers of several institutions but few studies have been conducted in ICAR laboratories. Hence this study has been

undertaken on CTCRI, one of the prestigious institutions of ICAR.

### Objectives of the study

This study has the following objectives:

1. To ascertain the research productivity of CTCRI during 2000 -2010;
2. To examine the year-wise distribution of publications and to identify its various forms;
3. To examine the year-wise break up of articles in Indian and Foreign journals;
4. To determine the authorship pattern, collaboration among scientists and most productive authors;
5. To determine the most productive journals in which the scientists publish their articles;
6. To identify the country-wise distribution of journals; and
7. To study the applicability of Bradford's Law of Scattering.

### Methodology

The main objective of the study is to make an assessment, in quantitative terms with respect to the publications from CTCRI during the period 2000 to 2010. The annual reports of the centre for the period from 2000 – 2010 were used as the main source of data. Since the annual reports of academic as well as research organizations usually present a synoptic appraisal of research publications, the same have been used as the source data. Moreover these are the authentic source of information which reflects the overall activities of the institution. A total of 1076 publications of the CTCRI scientists during 2000 – 2010 formed the basic data for this study. All the bibliographic details of publications were transferred to a spreadsheet application. After validation, the data was analyzed as per the requirement of the study. The bibliographic data was analyzed by normal count procedure using scientometric techniques.

### Analysis

#### *Year – wise distribution of publications*

Year-wise distribution of publications is an important indicator of publication productivity of an institution. The total productivity of scientists of CTCRI for the eleven year period (2000-2010) under study is given chronologically in Table 1.

From the Table 1, it is observed that the total published literature for the 11 year period amounts to 1076. It includes journal articles, books, book chapters, working papers, conference papers, online sources and other publications. The year-wise productivity analysis of the published literature indicates that 2006 was the most productive year with 169 (15.70%) publications followed by 2004 with 147 (13.67%) publications and 2008 with 112 (10.4%) publications. The analysis shows that there is an average growth of publications during the period of study.

### Publication channels

Publishing productivity is often used as an index of departmental and institutional prestige and is strongly associated with an individual faculty member's reputation, visibility, and advancement in the academic reward structure, particularly at research institutions. The productivity of scientists of CTCRI are spread over a variety of publication media like journal articles, books, book chapters, working papers and other publications. The publication channels used by CTCRI scientists during the period under study is shown in the Table 2.

Table 1—Year-wise distribution of publications

Year	No. of publications	Percentage
2000	40	3.71
2001	81	7.52
2002	95	8.82
2003	90	8.37
2004	147	13.67
2005	101	9.4
2006	169	15.70
2007	81	7.52
2008	112	10.4
2009	102	9.48
2010	58	5.41
Total	1076	100.00

Table 2—Source form of publications

Sl. No.	Forms	No. of publications	Percentage
1	Journals	318	29.56
2	Technical Bulletins	19	1.77
3	Technical Journals	95	8.82
4	Books	10	0.92
5	Books Chapters	53	4.92
6	Seminar Proceedings	133	12.37
7	Working Papers	34	3.16
8	Conferences	185	17.20
9	Online	16	1.50
10	Symposium	146	13.56
11	Meetings	46	4.27
12	Others	21	1.95
	Total	1076	100.00

Articles in learned journals, seminars and conference papers are the prominent forms of contributions. The major contribution of 318 articles is in the form of journal articles which is about 29.56 % of the total publications. This is followed by 185 (17.20%) conference papers and 133 (12.37%) seminar papers. The publication output in the form of books, chapters in books are relatively low compared to the others. They together account for 63 contributions.

### Gender - wise distribution

Most of the publications in CTCRI are contributions of males with 762 publications (70.81%). The contributions of female scientists constitute 314 publications (29.19%).

### Rank list of most productive authors

The study reveals that M. Nedunchezhiyan is the most productive author contributing 50 publications followed by G. Suja with 46 publications, K. Susan John with 45 publications.

### Authorship pattern of publications

It is seen that only 12.63% (136) of publications are single authored and two and more than two authored publications are contributing more to the remaining 87.38% (940). It indicates that the multi authored works are more than that of single authored contributions.

Table 3—Rank list of most productive authors

Sl. No	Author	Rank	No. of publications	Percentage
1	M.Nedunchezhiyan	1	50	4.64
2	G.Suja	2	46	4.27
3	K.Susan John	3	45	4.18
4	T.Srinivas	4	36	3.34
5	A.Mukherjee	5	33	3.06
6	M.S. Sajeew	5	33	3.06
7	S.Edison	6	28	2.60
8	James George	7	23	2.13
9	J.T.Sheriff	7	23	2.13
10	M.L. Jeeva	8	22	2.04
11	T. Maheshkumar	8	22	2.04
12	R.S.Misra	8	22	2.04
13	B.Vimala	8	22	2.04
14	M.Anantharaman	9	21	1.95
15	G.Padmaja	10	20	1.85
16	S.K. Naskar	11	18	1.67
17	M.S.Palaniswami	11	18	1.67
18	A.N.Jyothi	12	17	1.57
19	M.N.Sheela	12	17	1.57
20	M.Unnikrishnan	12	17	1.57

Table 4—Authorship pattern of publications

Sl. No.	No. of authors	No. of articles	Percentage
1	Single authors	136	12.62
2	Two authors	276	25.67
3	Three authors	297	27.60
4	Four authors	210	19.51
5	More than four authors	157	14.60
	Total	1076	100.00

### Degree of collaboration of publications

Collaboration is said to have taken place when two or more investigators work together on a project and contribute resources and effort, both intellectual and physical. The degree of collaboration varies from one discipline to another. Extend of collaboration can be measured with the help of multi- authored papers. To measure the collaborative research pattern a simple indicator called collaboration coefficient is used. Collaboration co-efficient is the ratio of the number of collaborative research papers during a certain period of time. As per the formula given by Subramanyam<sup>31</sup>, for determining the degree of collaboration in a discipline, the value of collaboration will be between 0 and 1.

To determine the degree of collaboration of publications, the number of single authored and multi-authored publications are calculated using the formula the formula:  $C = N_m / (N_m + N_s)$

$C =$  Degree of Collaboration

$N_m =$  Number of multi authored papers

$N_s =$  Number of single authored papers

$$\text{Here } C = \frac{940}{940 + 136} = 0.87$$

Hence the Degree of Collaboration of publications of the CTCRI scientists is 0.87.

### Analysis of journal articles

#### Year - wise distribution of foreign and Indian journal articles

The analysis of distribution of articles reveals that 153(48.11%) were published in Indian journals and 165 articles (51.89%) were published in foreign journals. The year 2008 is the most productive year in the case of journal articles. Out of the 43 total

Table5—Year-wise distribution of foreign and Indian journals

Year	Articles in foreign journals	Articles in Indian journals	Total number of articles
2000	1	19	20
2001	5	18	23
2002	12	10	22
2003	6	15	21
2004	20	6	26
2005	24	9	33
2006	26	9	35
2007	21	11	33
2008	22	21	43
2009	19	21	40
2010	9	14	23
Total	165(51.89%)	153(48.11%)	318(100.00%)

Table 6—Authorship pattern of journal articles

Sl. No.	No. of authors	No. of articles	Percentage
1	Single author	16	5.03
2	Two authors	88	27.68
3	Three authors	95	29.88
4	Four authors	73	22.95
5	More than four authors	46	14.46
	Total	318	100.00

articles published in the year 2008, twenty two are in the foreign journals and 21 are published in Indian journals.

### Authorship pattern of journal articles

It is seen from the Table 6 that most of the journal articles are by three authors. Ninety five (29.88%) of them are written by three authors and 88 are by two authors.

### Degree of collaboration of journal articles

To measure the collaborative research pattern a simple indicator called collaboration coefficient is used. Collaboration co-efficient is the ratio of the number of collaborative research papers during a certain period of time.

To determine the degree of collaboration of journal articles, the number of single authored and multi-authored are calculated, and the values are shown in the Table 7.

### Ranked authors of journal articles.

The study reveals that M. Nedunchezhiyan is the most productive author contributing 25 journal articles, followed by G. Suja with 14 articles and T. Srinivas with 13 articles.

Table 7—Degree of collaboration of journal articles

Year	No. of single authored articles	No. of multi authored articles	Total	Degree of Collaboration $C=Nm/(Nm+Ns)$
2000	2	18	20	0.90
2001	1	22	23	0.95
2002	1	21	22	0.95
2003	1	20	21	0.95
2004	2	24	26	0.92
2005	1	32	33	0.96
2006	1	34	35	0.97
2007	2	30	32	0.93
2008	3	40	43	0.93
2009	2	38	40	0.95
2010	1	22	23	0.95
Total	17	301	318	0.94(Average)

### Rank list of journals

The rank list of top 15 journals is listed in the Table 9. It gives the rank list of most productive journals with a minimum of 4 articles.

From Table 9 it is seen that *Journal of Root Crops* an Indian journal published by Indian Society of root crops top the list with the highest number of articles 128 (40.25%). It is followed by *Starch/Strake* with a share of 13(4.08%) and *Aroideana* occupy the third position with 9(2.83 %) publications.

### Scattering of journal articles and Bradford's law

As an indicator of the dispersion of scientific output, S. C. Bradford<sup>32</sup> proposed a model of concentric productivity zones with a decreasing information density. In other words each zone or core contains a similar number of articles, but the number of journals in which these are published increases from one zone to the next according to the expression  $1: n: n^2$ , in this way, a group of journals dedicated more specifically to the subject of interest can be distinguished. The law states that if a large collection of articles is ranked in the order of decreasing productivity of journals relevant to the given topic, three zones can be marked off so that each zone produces  $1/3^{rd}$  of the total relevant pages.<sup>33</sup>

For testing the algebraic interpretation of the law, 98 journal titles are divided into three zones. The Bradford's multiplier factor was arrived by dividing periodical titles of a zone by its preceding zone. The distribution of journals and corresponding number of articles in the three

Table 8—Rank list of top 10 authors

Sl. No.	Author	No. of journal articles	Rank
1	M.Nedunchezhiyan	25	1
2	G.Suja	14	2
3	T.Srinivas	13	3
4	A.N.Jyothi	12	4
5	S.Jisha	10	5
6	K.Susan John	10	5
7	G.Byju	9	6
8	M.L.Jeeva	9	6
9	M.R.Swain	9	6
10	R.S.Misra	7	7

zones along with the value of Bradford multipliers are shown in Table 10.

In the present data set one journal covers 128 articles, next 23 journals cover 105 articles and remaining 74 journals cover 85 articles. In other words, one third of the total articles have been covered by each group of journals. According to Bradford, the zones thus identified will form an approximately geometric series in the form  $1: n: n^2$ . But it is found that the relationship of each zone in the present study is 1:23:74. This does not fit into the Bradford's distribution.

Here, 1 represent the number of journals in the nucleus and  $n= 27.60$  is a multiplier, the mean value of multiplier is 27.60.

$$\text{Therefore } 1 : 1 \times 27.60 : 1 \times 27.60^2 :: 1: n : n^2$$

$$1: 27.60 : 761.76 \gg 790.36$$

$$\text{The Percentage error} = \frac{790.36 - 98}{98} \times 100 = 706.49 \%$$

Since the percentage error is very high, the data will not fit well the Bradford's law of Scattering<sup>34</sup>.

### Conclusion

Publication productivity has been used as a criterion to assess the research output of individual scholars, academic programs and institutions. Studies consistently indicate that there exists enormous variation in scientist's levels of productivity. The analysis of publication productivity of CTCRI scientists shows that there is an increasing trend of publication growth. A total of 318 journal articles, 185 conference papers, 34 working papers, etc are published by the scientists during the period under

Table 9—Rank list of journals

Sl No. Journals	Publisher	Country	No. of articles	Rank	Percentage
1 <i>Journal of Root crops</i>	Indian society of root crops	India	128	1	40.25
2 <i>Starch/Strake</i>	Wiley Blackwell	UK	13	2	4.08
3 <i>Aroideana</i>	Journal of the International Aroid Society	New York	9	3	2.83
4 <i>Advances in Horticultural Science</i>	University of Florence Italy	UK	5	4	1.57
5 <i>Indian Journal of Agricultural Sciences</i>	Indian Council of Agricultural Research.	India	5	4	1.57
6 <i>Indian Journal of Mycology and Plant Pathology</i>	Indian Society of Mycology and Plant Pathology	India	4	4	1.25
7 <i>Journal of Food Science and Technology</i>	Springer India	India	4	4	1.25
8 <i>Innovative Food Science and Emerging Technologies</i>	Elsevier	Netherlands	4	5	1.25
9 <i>Indian Journal of Horticulture</i>	Horticultural Society of India	India	4	5	1.25
10 <i>Annals of Plant Protection Sciences</i>	Society of Plant Protection Sciences	India	4	5	1.25
11 <i>Annals of Tropical Research</i>	Visayas State University	Philippines	4	5	1.25
12 <i>Food and Bioprocess Technology</i>	Springer New York	United States	4	5	1.25
13 <i>The Orissa Journal of Horticulture</i>	The Orissa Horticultural society	India	4	5	1.25
14 <i>Journal of the Indian Society of Soil Sciences</i>	The Indian Society of Soil Science	India	4	5	1.25
15 <i>Journal of Economic Entomology</i>	Entomological Society of America	United States	4	5	1.25

Table 10—Scattering of journals and articles over Bradford Zone

Zones	No. of journals	Percentage of journals	No. of articles	Percentage of articles	Multiplier
1	1	1.02	128	40.26	-
2	23	23.47	105	33.01	23.00
3	74	75.51	85	26.73	32.17
Total	98	100.00	318	100.00	27.60(Average)

study. Journal articles are the most preferred form of publications of CTCRI scientists and it amounts to 1/3<sup>rd</sup> of the total publications. The scientists prefer mostly foreign journals to publish their articles. The foreign journals contribute the highest number of articles. Among the subject multi author contributions predominate which shows a high degree of collaboration in the science field. The productivity of scientists of CTCRI shows substantial growth both quantitatively and qualitatively with the development of the institution. Analysis revealed that the female contributions are very less. Therefore more attention may be taken for increasing the number of female researchers and scientists. There is an urgent need for the bibliographic control of CTCRI publications and creation of a comprehensive database of publication.

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